

PATENT
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APPLICATION FOR UNITED STATES LETTERS PATENT

for

**FUNCTIONALIZED VEGETABLE OIL DERIVATIVES,
LATEX COMPOSITIONS AND COATINGS**

by

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BACKGROUND OF THE INVENTION

The present invention is directed to vegetable oil derivatives. More particularly, the present invention is directed to functionalized vegetable oil derivatives that can be used in latexes and coatings.

One problem encountered by coatings manufacturers is the development of formulations containing low VOC-coalescing aids or plasticizers. For instance, emulsion polymers are currently formulated with coalescing aids or plasticizers in order to form films at and below ambient conditions yet dry to films of sufficient glass transition temperature (T_g) to perform adequately at and above room temperature. In general, the ability of emulsion polymers to form or coalesce into film is governed by the minimum film forming temperature (MFT) of the polymer in question. Low MFT polymers are required in order to exhibit coalescence, flow, and surface wetting properties. However, if the polymer remains soft and tacky, the coatings are not usable. Therefore, it is necessary to develop a technology in which coating formulations contain suitable ingredients to provide an initial low MFT, which, upon application, form nontacky, durable, hard, and water resistant surfaces having a T_g significantly above their MFT.

Various other coating compositions which cure under ambient conditions are known in the prior art. A few such examples involve curing by a chemical reaction such as epoxide-carboxylic acid reaction, isocyanate-moisture reaction, polyaziridine-carboxylic acid reaction, and activated methylene-unsaturated acrylic reaction.

Recently, a number of new latex or emulsion compositions derived from semi-drying and/or non-drying oils have been developed for use in coatings, adhesives and inks. Such compositions are disclosed in U.S. Patents Nos. 6,001,913; 6,174,948; and 6,203,720 each of which is incorporated herein by reference in its entirety.

The search for additional compositions that can be used in latexes and coatings is continuing. Accordingly, it would be an advancement in the art to provide compositions that can be made from renewable resources that are suitable for use in latexes and coatings.

SUMMARY OF THE INVENTION

The present invention is directed to functionalized vegetable oil derivatives which are useful in latexes and coatings. In the preferred embodiment, an ethylenically

1 unsaturated vegetable oil is modified by the addition of an enophile or dienophile having
2 an acid, ester or anhydride functionality The modified vegetable oil is then reacted with a
3 functional vinyl monomer to form the vegetable oil derivative. Suitable monomers
4 include hydroxy, amine, thiol, oxirane vinyl monomers.

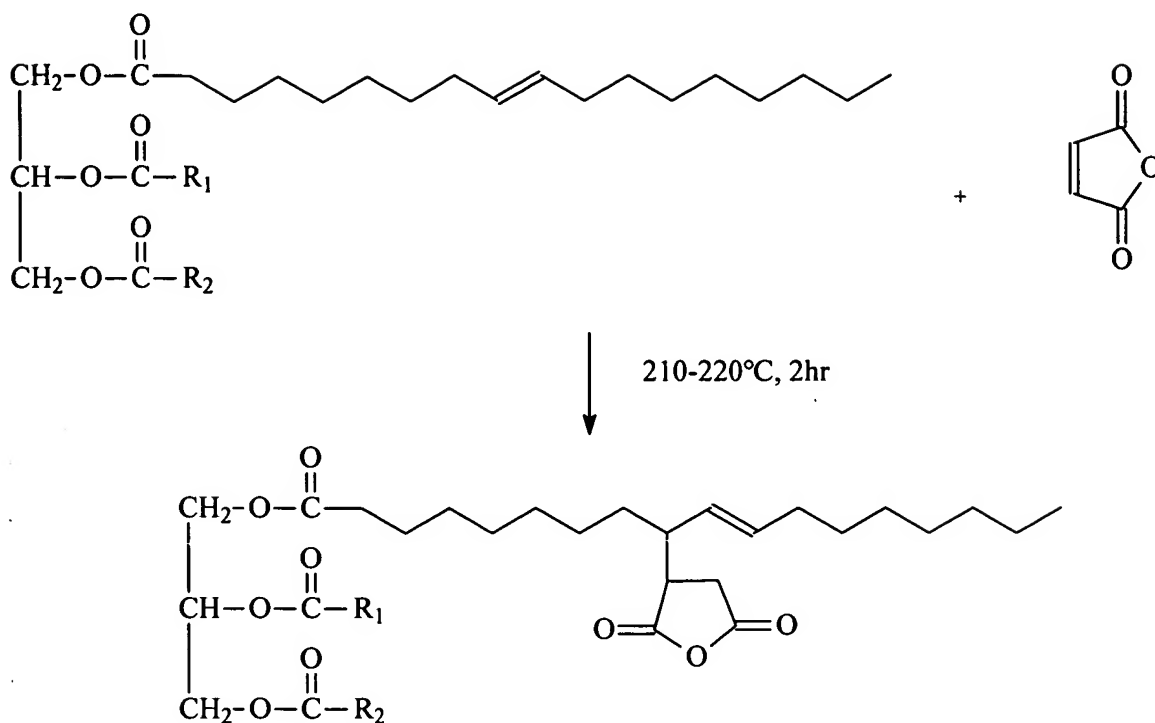
5 The functionalized vegetable oil derivatives can be formulated into latexes and
6 other coating compositions.

7 **DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS**

8 The present invention is directed to a series of vegetable oil macromonomers and
9 their use in latexes and coatings. The invention is also directed to the method of
10 producing these macromonomers. This set of monomers is derived by reacting
11 unsaturated vegetable oils with an enophile or dienophile having an acid, ester or
12 anhydride functionality, and then reacting the derivative with a suitable hydroxy, amine,
13 thiol, oxirane, or other functional vinyl monomer.

14 In a preferred embodiment, an unsaturated vegetable oil, such as soybean oil is
15 reacted with maleic anhydride to form a maleinized vegetable oil as schematically shown
16 in Reaction 1. Preferably, the reaction is performed at a temperature of about 200 °C to
17 about 240 °C. More preferably, the reaction is performed at a temperature of about 210
18 °C to about 220 °C.

Reaction 1:



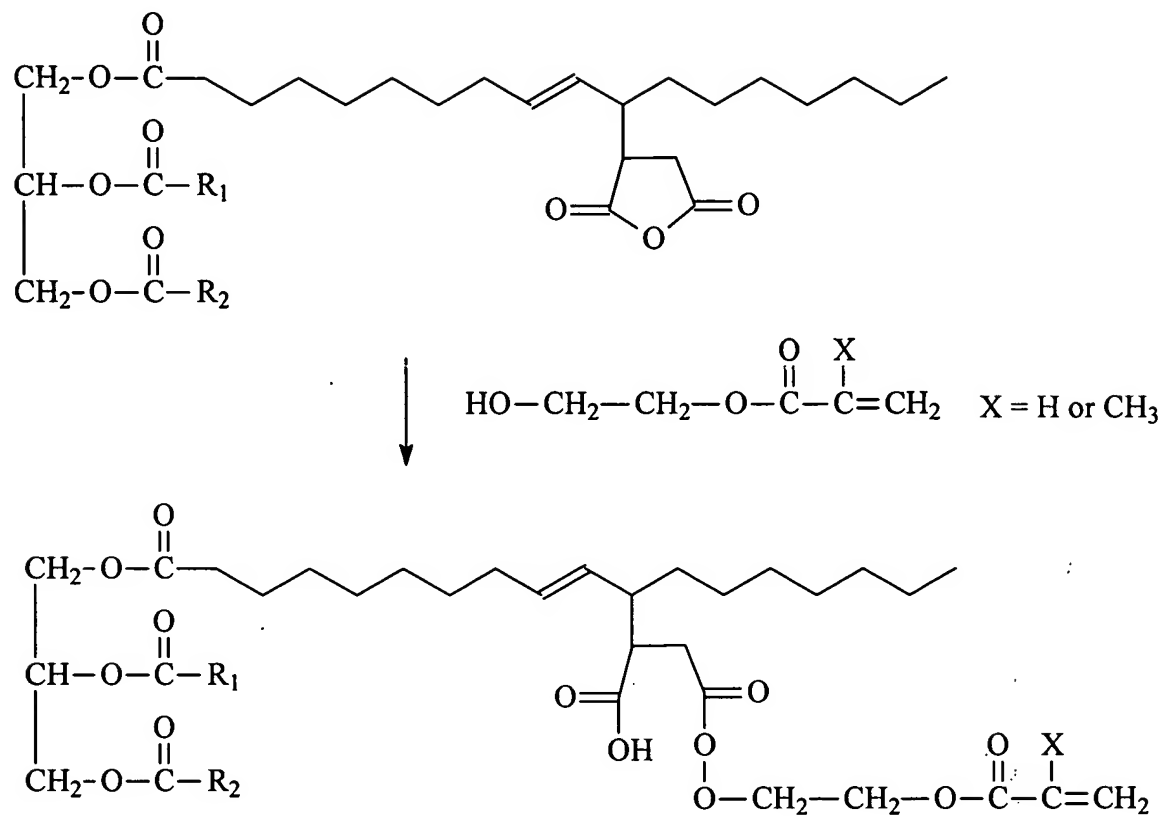
Any unsaturated vegetable oil can be used in the present invention. However, linseed oil, soybean oil and sunflower oil are preferred.

Many different compounds can be used to modify the unsaturated vegetable oil. They include enophiles and dienophiles that contain acid, ester or anhydride functionality. Examples include but are not limited to maleic anhydride, fumaric acid, itaconic anhydride and maleate esters.

The modified vegetable oil is then reacted with a suitable functional vinyl monomer to form the macromonomers of the present invention. A series of exemplary reactions are illustrated in Reactions 2a-2e. In Reaction 2a, the maleinized vegetable oil is reacted with hydroxyethyl acrylate (HEA) or hydroxyethyl methacrylate (HEMA). In Reaction 2b, the maleinized vegetable oil is reacted with 2-(tert-butylamino)ethyl methacrylate (BAEMA). In Reaction 2c, the maleinized vegetable oil is reacted with glycidyl acrylate (GA) or glycidyl methacrylate (GMA). In Reaction 2d, the maleinized vegetable oil is reacted with allyl amine. Finally, in Reaction 2e, the maleinized

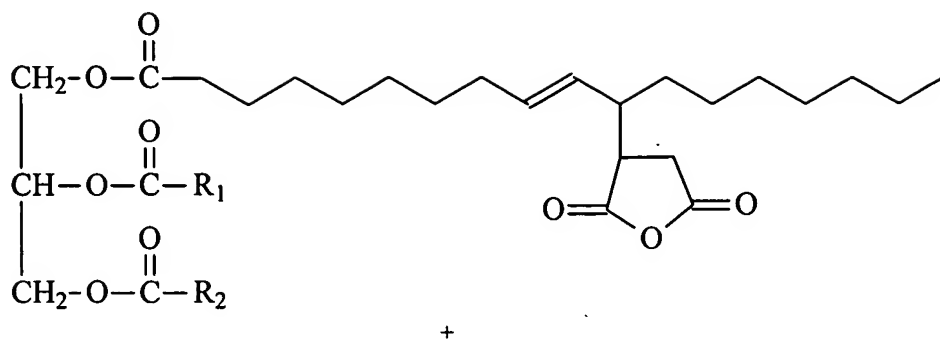
vegetable oil is reacted with a vinyl ether such as hydroxybutyl vinyl ether where R is $-(CH_2)_4-$.

Reaction 2a

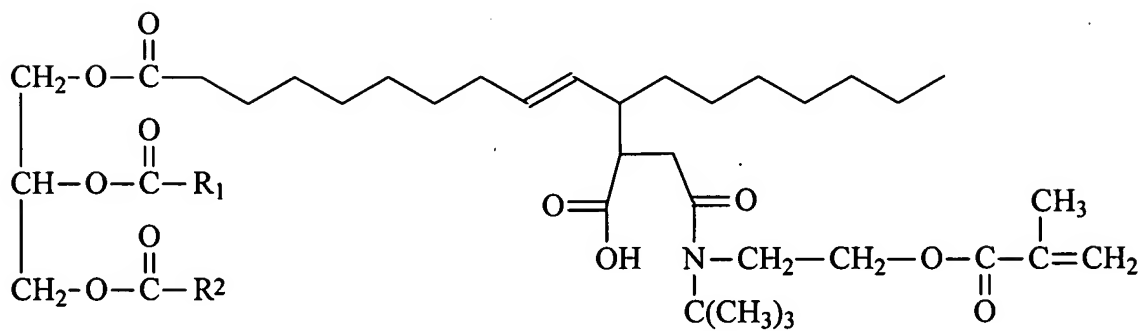
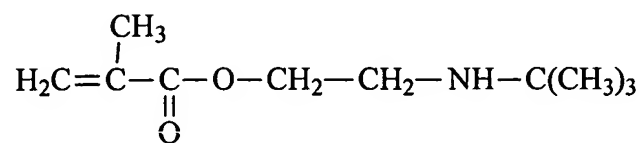


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Reaction 2b

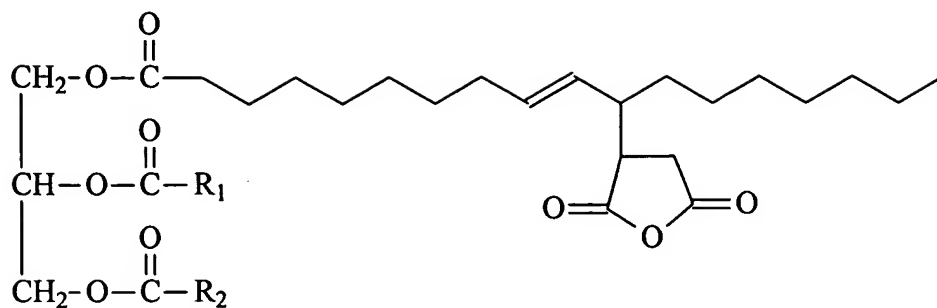


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1 **Reaction 2c**

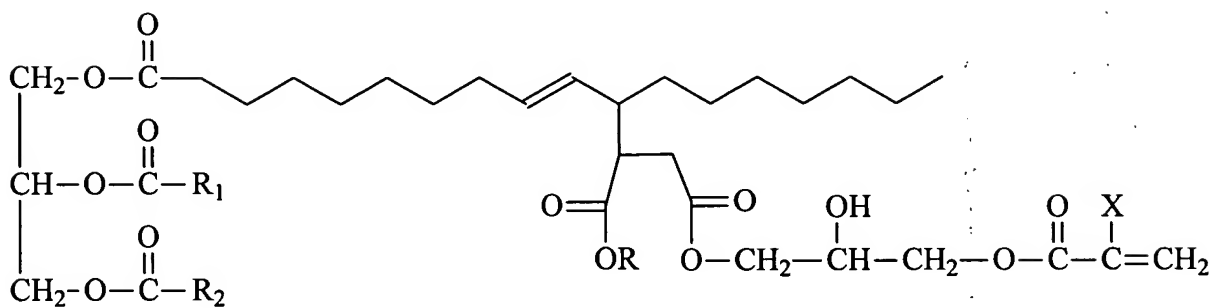
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1. HO-R

2. $\text{H}_2\text{C}-\text{CH}-\text{CH}_2-\text{O}-\text{C}(=\text{O})-\text{C}(\text{X})=\text{CH}_2$ X = H or CH₃

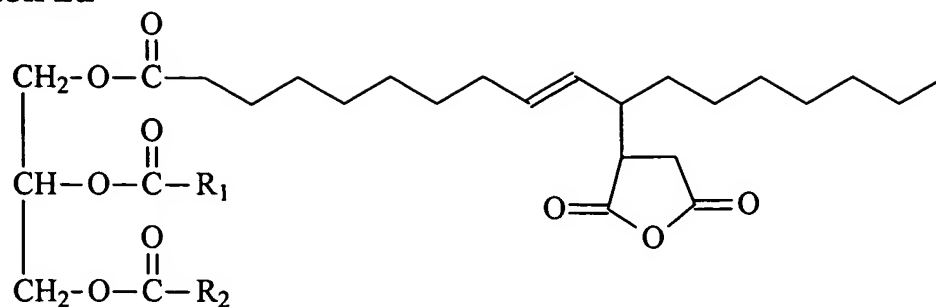


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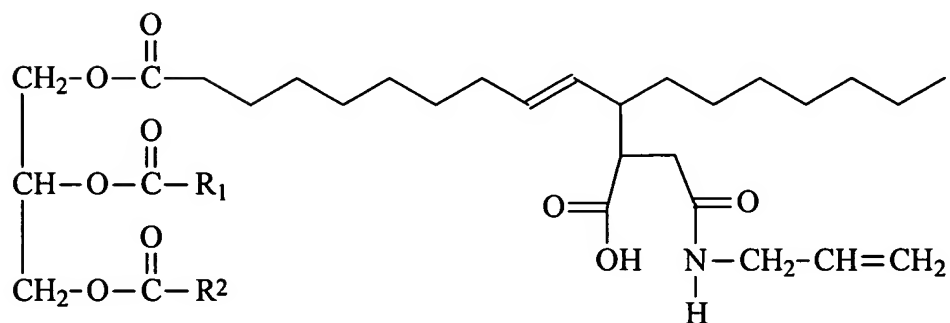
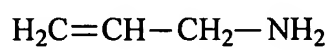
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1 **Reaction 2d**



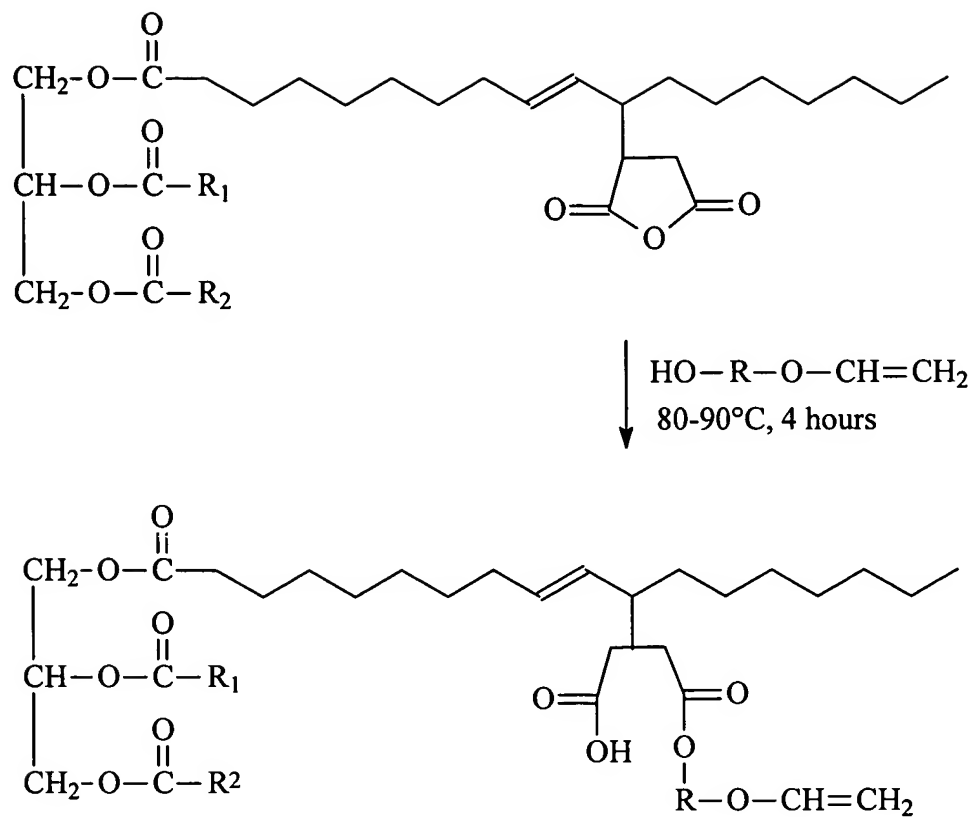
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1 **Reaction 2e**

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1 Examples of additional functionalized vinyl monomers that can be used in the
2 present invention include, but are not limited to, hydroxypropyl acrylate, hydroxypropyl
3 methacrylate, hydroxybutyl acrylate, hydroxybutyl methacrylate, allyl alcohol, 3-butenol,
4 acrylamide and methacrylamide.

5 The macromonomers of the present invention can be used to make latexes and
6 coatings compositions. In the preferred embodiment, the latexes are formed in a staged
7 polymerization process as disclosed in published U.S. Application 2003/0045609, the
8 teachings of which are hereby incorporated by reference. However, non-staged latex
9 polymerization processes can also be used.

10 The modified vegetable oils of the present invention can then be copolymerized
11 with conventional functionalized monomers in emulsion polymerization processes to
12 produce vinyl polymers.

13 The invention is further understood by reference to the following examples which
14 describe the formation of various macromonomers as well as the formulation of latexes
15 and coatings.

16 17 18 **Example 1** 19

20 Soybean oil (51.03 kg) was heated in a reactor to 100°C, and nitrogen gas was
21 passed through the reaction mixture to remove the oxygen in the system. Maleic
22 anhydride (14.17 kg) and xylene (2.93 mL) were added and the temperature was slowly
23 raised to 205-210°C and held for 2.5 hours. The maleic anhydride concentration was
24 followed via gas chromatography (GC). Heating was stopped when the maleic anhydride
25 concentration reached 1-2%, and the reaction mixture was cooled to 90°C.

26 Phenothiazine (86 g) was mixed with hydroxyethyl acrylate (13.30 kg) and added
27 to the reactor. Next, 86 g of phosphoric acid (85% solution in water) was added to the
28 reaction mixture. The temperature was raised to 110-115°C and heating was continued
29 for 2.5 hours. Heating was stopped when the hydroxyethyl acrylate concentration
30 dropped below 4% (determined by GC). The reaction mixture was cooled to 60-70°C
31 and the reaction product, monomer 'A' was discharged.
32

Example 2

Maleic anhydride (48 g) was mixed with linseed oil (152 g) and nitrogen gas was passed through the reaction mixture to remove the oxygen in the system. The reaction mixture was heated to 150°C over 30 minutes and then heated to 200°C where it was held for 2.5 hours. The reaction mixture was cooled to 50°C, and hydroxyethyl acrylate (58 g), phenothiazine (0.25 g), and phosphoric acid, 85% solution in water (0.25 g) were added to the reaction mixture. The reaction was continued for 3-5 hours at 80°C till all the hydroxyethyl acrylate had reacted to yield monomer 'B'.

Example 3

Maleic anhydride (72 g) was mixed with soybean oil (221 g) and nitrogen gas was passed through the reaction mixture to remove the oxygen in the system. The reaction mixture was heated to 150°C over 30 minutes and then heated to 200°C where it was held for 2.5 hours. The reaction mixture was cooled to 50°C, and hydroxyethyl methacrylate (105 g), phenothiazine (0.25 g), and 1-methyl imidazole (0.30 g) were added to the reaction mixture. The reaction was continued for 3-5 hours at 110°C till all the hydroxyethyl acrylate had reacted to yield monomer 'C'.

Example 4

Maleic anhydride (46 g) was mixed with linseed oil (215 g) and nitrogen gas was passed through the reaction mixture to remove the oxygen in the system. The reaction mixture was heated to 150°C over 30 minutes and then heated to 200°C where it was held for 2.5 hours. The reaction mixture was cooled to 50°C, and hydroxyethyl acrylate (61 g), phenothiazine (0.25 g), and phosphoric acid, 85% solution in water (0.3 g) were added to the reaction mixture. The reaction was continued for 3-5 hours at 110°C till all the hydroxyethyl acrylate had reacted to yield monomer 'D'.

Example 5

Maleic anhydride (477 g) was mixed with soybean oil (2150 g) and nitrogen gas was passed through the reaction mixture to remove the oxygen in the system. The reaction mixture was heated to 150°C over 30 minutes and then heated to 215°C where it was held for 2 hours. The reaction mixture was cooled to 90°C, and hydroxyethyl acrylate (565 g), phenothiazine (5 g), and phosphoric acid, 85% solution in water (5 g) were added to the reaction mixture. The reaction was continued for 4-5 hours at 110°C till all the hydroxyethyl acrylate had reacted to yield monomer 'E'.

Example 6

Soybean oil (51.03 kg) was heated in a reactor to 100°C, and nitrogen gas was passed through the reaction mixture to remove the oxygen in the system. Maleic anhydride (11.21 kg) and xylene (2.93 mL) were added and the temperature was slowly raised to 205-210°C and held for 2.5 hours. The maleic anhydride concentration was followed via GC. Heating was stopped when the maleic anhydride concentration reached 1-2%, and the reaction mixture was cooled to 90°C.

Phenothiazine (50 g) was mixed with hydroxyethyl acrylate (8.99 kg) and added to the reactor. Next, 81 g of phosphoric acid (85% solution in water) was added to the reaction mixture. The temperature was raised to 120°C and heating was continued for 2.5 hours. Heating was stopped when the hydroxyethyl acrylate concentration dropped below 4% (determined by GC). The reaction mixture was cooled to 60-70°C and the reaction product, monomer 'F', was discharged.

Example 7

Linseed oil (51.03 kg) was heated in a reactor to 100°C, and nitrogen gas was passed through the reaction mixture to remove the oxygen in the system. Maleic anhydride (11.21 kg) and xylene (2.93 mL) were added and the temperature was slowly raised to 205-210°C and held for 2.5 hours. The maleic anhydride concentration was followed via GC. Heating was stopped when the maleic anhydride concentration reached 1-2%, and the reaction mixture was cooled to 90°C.

Phenothiazine (50 g) was mixed with hydroxyethyl acrylate (8.99 kg) and added to the reactor. Next, 81 g of phosphoric acid (85% solution in water) was added to the

1 reaction mixture. The temperature was raised to 120°C and heating was continued for 2.5
2 hours. Heating was stopped when the hydroxyethyl acrylate concentration dropped
3 below 4% (determined by GC). The reaction mixture was cooled to 60-70°C and the
4 reaction product, monomer 'G', was discharged.

5 **Example 8**

6 Soybean oil (981 g) was heated in a reactor to 100°C, and nitrogen gas was
7 passed through the reaction mixture to remove the oxygen in the system. Maleic
8 anhydride (323 g) and xylene (1 drop) were added and the temperature was slowly raised
9 to 205-210°C and held for 4.5 hours. The maleic anhydride concentration was followed
10 via GC. Heating was stopped when the maleic anhydride concentration reached 1-2%,
11 and the reaction mixture was cooled to 90°C.

12 Phenothiazine (1.35 g) was mixed with hydroxyethyl acrylate (253 g) and added to
13 the reactor. Next, 1.54 g of phosphoric acid (85% solution in water) was added to the
14 reaction mixture. The temperature was raised to 120°C and heating was continued for 3
15 hours. The reaction mixture was cooled to 60-70°C and the reaction product, monomer
16 'H', was discharged.

17 **Example 9**

18
19 Soybean oil (981 g) was heated in a reactor to 100°C, and nitrogen gas was
20 passed through the reaction mixture to remove the oxygen in the system. Maleic
21 anhydride (323 g) and xylene (1 drop) were added and the temperature was slowly raised
22 to 205-210°C and held for 4.5 hours. The maleic anhydride concentration was followed
23 via GC. Heating was stopped when the maleic anhydride concentration reached 1-2%,
24 and the reaction mixture was cooled to 90°C.

25 Phenothiazine (1.35 g) was mixed with hydroxyethyl methacrylate (305 g) and
26 added to the reactor. Next, 1-methyl imidazole (1.54 g) was added to the reaction
27 mixture. The temperature was raised to 120°C and heating was continued for 3 hours.
28 The reaction mixture was cooled to 60-70°C and the reaction product, monomer 'I', was
29 discharged.

Example 10

Linseed oil (152 g) was heated in a reactor to 100°C, and nitrogen gas was passed through the reaction mixture to remove the oxygen in the system. Maleic anhydride (48 g) and xylene (1 drop) were added and the temperature was slowly raised to 205-210°C and held for 4.5 hours. The maleic anhydride concentration was followed via GC. Heating was stopped when the maleic anhydride concentration reached 1-2%, and the reaction mixture was cooled to 90°C.

Phenothiazine (0.5 g) was mixed with hydroxyethyl methacrylate (75 g) and added to the reactor. Next, 0.5 g of phosphoric acid (85% solution in water) was added to the reaction mixture. The temperature was raised to 100°C and heating was continued for 4-5 hours. The reaction mixture was cooled to 60-70°C and the reaction product monomer 'J', was discharged.

Example 11

Sunflower oil (52.6 kg) was heated in a reactor to 100°C, and nitrogen gas was passed through the reaction mixture to remove the oxygen in the system. Maleic anhydride (11.57 kg) was added and the temperature was slowly raised to 205-210°C and held for 2.5 hours. The maleic anhydride concentration was followed via GC. Heating was stopped when the maleic anhydride concentration reached 1-2%, and the reaction mixture was cooled to 90°C.

Phenothiazine (125 g) was mixed with hydroxyethyl acrylate (13.69 kg) and added to the reactor. Next, 125 g of phosphoric acid (85% solution in water) was added to the reaction mixture. The temperature was raised to 100°C and heating was continued for 4-5 hours. The reaction mixture was cooled to 60-70°C and the reaction product monomer 'K' was discharged.

Example 12

Maleic anhydride (48 g) was mixed with sunflower oil (152 g) and nitrogen gas was passed through the reaction mixture to remove the oxygen in the system. The reaction mixture was heated to 150°C over 30 minutes and then heated to 200°C where it was held for 2.5 hours. The reaction mixture was cooled to 50°C, and hydroxyethyl

1 acrylate (58 g), phenothiazine (0.25 g), and phosphoric acid, 85% solution in water (0.25
2 g) were added to the reaction mixture. The reaction was continued for 3-5 hours at 80°C
3 till all the hydroxyethyl acrylate had reacted to yield monomer 'L'.

4 **Example 13**

5
6 Maleic anhydride (49 g) was mixed with soybean oil (221 g) and nitrogen gas was
7 passed through the reaction mixture to remove the oxygen in the system. The reaction
8 mixture was heated to 150°C over 30 minutes and then heated to 200°C where it was held
9 for 2.5 hours. The reaction mixture was cooled to 50°C, and styrene (100 g), and allyl
10 amine (28 g) were added to the reaction mixture. The reaction was continued for 5 hours
11 at 50°C to yield monomer 'M'.

12 **Example 14**

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14
15 Maleic anhydride (49 g) and 2-methylmercaptobenzoylthiazole (0.1 g) were
16 mixed with soybean oil (221 g) and nitrogen gas was passed through the reaction mixture
17 to remove the oxygen in the system. The reaction mixture was heated to 150°C over 30
18 minutes and then heated to 215°C where it was held for 2.5 hours. The reaction mixture
19 was cooled to 70°C, and phenothiazine (0.35 g), and 2-(*tert*-butyl amino) ethyl
20 methacrylate (92 g) were added to the reaction mixture. The reaction was continued for 5
21 hours at 80°C to yield monomer 'N'.

22 **Example 15**

23
24
25 Maleic anhydride (49 g) and 2-methylmercaptobenzoylthiazole (0.1 g) were
26 mixed with soybean oil (221 g) and nitrogen gas was passed through the reaction mixture
27 to remove the oxygen in the system. The reaction mixture was heated to 150°C over 30
28 minutes, and then heated to 215°C where it was held for 2.5 hours. The reaction mixture
29 was cooled to 90°C, and water (27 g) was added to the reaction mixture. The reaction
30 was continued for 2.5 hours at 95°C. Then phenothiazine (0.35 g), glycidyl acrylate (128
31 g), and tetramethylammonium chloride (1 g) were added. The reaction was continued for
32 4 hours at 100°C to yield monomer 'O'.

Example 16

Maleic anhydride (49 g) and xylene (0.1 g) were mixed with soybean oil (221 g) and nitrogen gas was passed through the reaction mixture to remove the oxygen in the system. The reaction mixture was heated to 150°C over 30 minutes and then heated to 215°C where it was held for 2.5 hours. The reaction mixture was cooled to 90°C, and poly(ethylene glycol)monomethyl ether (140 g) and 1-methylimidazole (0.5 g) were added to the reaction mixture. The reaction was continued for 2.5 hours at 130°C. Next, phenothiazine (0.35 g), glycidyl methacrylate (56.8 g), and tetramethylammonium chloride (1 g) were added. The reaction was continued for 4 hours at 100°C to yield monomer 'P'.

Example 17

Soybean oil (981 g) was heated in a reactor to 100°C, and nitrogen gas was passed through the reaction mixture to remove the oxygen in the system. Maleic anhydride (197 g) and 2-mercaptobenzothiazole (0.363 g) were added and the temperature was slowly raised to 215-220°C and held for 2.5 hours. The maleic anhydride concentration was followed via GC. Heating was stopped when the maleic anhydride concentration reached 1-2%, and the reaction mixture was cooled to 90°C.

Phenothiazine (1.35 g) was mixed with hydroxybutyl vinyl ether (233 g) and added to the reactor. Next, 1-methyl imidazole (1.54 g) was added to the reaction mixture. The temperature was raised to 100°C and heating was continued for 2 hours. The reaction mixture was cooled to 60-70°C and the reaction product, monomer 'Q' was discharged.

Example 18

Latex synthesis

The first stage pre-emulsion was prepared by dissolving 0.005 lb (2.27 g) of Rhodapex CO 436, and 0.002 lb (0.91 g) of Igepal® CO-887 in 0.78 lb (353.38 g) of deionized water. Next, 0.072 lb (32.65 g) of butyl acrylate, 0.056 lb (25.40 g) of methyl methacrylate, and 0.0014 lb (0.64 g) of methacrylic acid was added and the mixture was

1 stirred at high speed for 20 minutes. The initiator solution was prepared by dissolving
2 0.02 lb (9.07 g) of ammonium persulfate in 0.177 lb (80.29 g) of deionized water.

3 The second stage pre-emulsion was prepared by dissolving 0.0146 lb (6.62 g) of
4 sodium bicarbonate, 0.092 lb (41.73 g) of Rhodapex[®] CO-436, and 0.034 lb (15.42 g) of
5 Igepal CO-887 in 1.48 lb (671.32 g) of deionized water. Next, 1.34 lb (607.81 g) of butyl
6 acrylate, 1.064 lb (482.62 g) of methyl methacrylate, 0.03 lb (13.61 g) of methacrylic
7 acid, 0.03 lb (13.61 g) of divinyl benzene, and 0.15 lb (68.25 g) of monomer 'F' were
8 added, and stirred for 5 minutes. An aqueous solution of diacetone acrylamide was
9 prepared by dissolving diacetone acrylamide (0.117 lb, 53.07 g) in deionized water
10 (0.132 lb, 59.87 g) and added to the pre-emulsion and stirred for 20 minutes at high
11 agitation.

12
13 A 1-gallon reactor was charged with 0.97 lb (439.98 g) of deionized water and
14 0.01 lb (4.54 g) of Rhodapex CO-436. The mixture was stirred well, purged with
15 nitrogen for 15 minutes, and heated to 80 ± 2 °C. The first stage pre-emulsion solution
16 and 0.035 lb (15.87 g) of the initiator solution were added to the reactor. 15 minutes
17 later, the second stage pre-emulsion, and the remaining initiator solution are fed into the
18 reactor at constant rate over 2.75 hours and 3.0 hours, respectively.

19 An oxidizer solution was prepared by dissolving 0.0032 lb (1.45 g) of *t*-butyl
20 hydroperoxide in 0.026 lb (11.79 g) of deionized water. A reducer solution was prepared
21 by dissolving 0.003 lb (1.36 g) of sodium metabisulfite in 0.026 lb (11.79 g) of deionized
22 water. The oxidizer and reducer solutions were charged to the reactor simultaneously
23 over 1.5 hours at a constant rate. The reactor was held at the same temperature for
24 another 30 minutes and cooled over 45 minutes to 35°C. Next, 0.57 lb (258.55 g) of
25 ammonia was added slowly under stirring.

26 In another container, 0.059 lb (26.76 g) of adipic dihydrazide was dissolved in
27 0.06 lb (27.21 g) of deionized water, and added slowly to the latex under stirring. Lastly,
28 the latex was filtered through a 100 mesh filter.

Example 19

Latex synthesis (continued)

Latexes with varying percentages of monomer 'F' were synthesized as follows. A latex without any vegetable oil monomer was synthesized and used as the control.

	2% Monomer 'F'	4% Monomer 'F'	6% Monomer 'F'	Control
Kettle Charge				
Deionized water	110.0	110.0	110.0	110.0
Rhodapex CO-436	1.2	1.2	1.2	1.2
Stage I				
Deionized water	166.9	166.9	166.9	166.9
Sodium bicarbonate	1.7	1.7	1.7	1.7
Rhodapex CO-436	10.4	10.4	10.4	10.4
Igepal CO-887	3.8	3.8	3.8	3.8
Butyl acrylate	165.0	160.0	156.0	169.0
Methyl methacrylate	123.0	121.0	120.0	125.0
Divinyl benzene	6.6	6.6	6.6	6.6
Methacrylic acid	3.2	3.2	3.2	3.2
Diacetone acrylamide	13.2	13.2	13.2	13.2
Monomer 'F'	6.2	12.4	18.8	0.0
Initiator				
Ammonium persulfate	2.2	2.2	2.2	2.2
Deionized water	22.0	22.0	22.0	22.0
Chaser				
Sodium metabisulfite	0.4	0.4	0.4	0.4
Deionized water	3.0	3.0	3.0	3.0
<i>t</i> -Butyl hydroperoxide	0.4	0.4	0.4	0.4
Deionized water	3.0	3.0	3.0	3.0
Ammonium hydroxide	2.1	2.1	2.1	2.1
Adipic dihydrazide	6.8	6.8	6.8	6.8
Total	650.9	650.1	651.5	650.7

Example 20

The latexes synthesized in examples 18 and 19 were formulated into semi-gloss coatings as per the following recipe.

Grind	Pounds	Gallons
Water	100.00	12.00
Natrosol® Plus 330	2.00	0.17
Potassium carbonate	2.50	0.13
Tamol® 2001	6.25	0.68
Drewplus® L-475	2.00	0.26
Triton® CF-10	1.00	0.11
Kathon® LX 1.5%	1.50	0.18
Ti-Pure® 706	230.00	6.90
Minugel® 400	5.0	0.25
Water	80.00	9.60
Total	430.25	30.30
Letdown		
Water	138.00	16.57
Drewplus® L-475	2.00	0.26
Strodex® PK	4.00	0.44
Drewthix® 864	1.00	0.11
Drewthix 4025	10.00	1.15
Latex	469.00	53.30
Total	1054.25	102.13

The coatings were evaluated for various properties, and the test results are listed in the following table.

	Control	2% Monomer 'F'	4% Monomer 'F'	6% Monomer 'F'
Stormer viscosity, KU	94.7	93.8	93.4	97.9
ICI viscosity, Poises	0.70	0.55	0.43	0.40
Gloss at 20°	20.0	17.3	17.2	16.6
Gloss at 60°	58.1	56.4	56.3	55.3
1-day block resistance	3.5	3.5	3.5	4.0
7-day block resistance	4.0	5.0	5.0	5.0
1 week scrub resistance	3039	2267	2354	1841

Example 21

Kettle Charge	
Deionized water	140.00
Stage I	
Deionized water	165.00
Rhodafac® RS-710	22.40
Ammonium bicarbonate	2.80
Methyl methacrylate	98.56
Butyl acrylate	103.60
Hydroxy ethyl acrylate	14.00
Silane	28.00
Monomer 'F'	28.00
Methacrylic acid	8.40
	470.76
Initiator	
Deionized water	25.00
Ammonium persulfate	0.39
<i>t</i> -Butyl hydroperoxide	0.76
Deionized water	25.50
Bruggolite® FF6	0.65
Chaser	
<i>t</i> -Butyl hydroperoxide	0.12
Deionized water	5.00
Bruggolite FF6	0.10
Deionized water	5.00
Total	673.29